AMERICAN JOURNAL OF PHYSICAL ANTHROPOLOGY 99:239–247 (1996)

Menarche Age, Fatness, and Fat Distribution in Hawaiian Adolescents

DANIEL E. BROWN, TUPOU V. KOENIG, ALEXIS M. DEMORALES, KA'OHULANI McGUIRE, AND CHARLENE T. MERSAI
Department of Anthropology, University of Hawaii at Hilo, Hilo, Hawaii 96720-4091 (D.E.B., A.M.D., K.McG, C.T.M.), and Pre-Kindergarten Education Program, Kamehameha Schools, Hilo, Hawaii 96720 (T.V.K.)

KEY WORDS Growth and development, Maturation, Adiposity, Hawaii

ABSTRACT Menarche age was assessed in 93 adolescent females in a sample of public schools in East Hawaii. Native Hawaiian girls had significantly lower reported age at menarche than non-Hawaiian classmates. Age at menarche was significantly correlated with total fatness as measured by the sum of six skinfolds in girls who had reached menarche at least 2 years previous to measurement. When fatness was controlled in comparisons, the ethnic differences were not significant. Fat distribution, independent of fatness, was also significantly related to age at menarche. Socioeconomic, cultural, and admixture variables were not significantly related to age at menarche. Adiposity appears to be both a cause and a consequence of early age at menarche, with the relationship dependent on the elapsed time between menarche and measurement. This suggests that studies relating body composition to age at menarche must carefully control for the time interval between measurement and the date of menarche.

There is some evidence that age at menarche among girls is related to degree of fatness (e.g., Maclure et al., 1991; Wellens et al., 1992). Early menarche age has been linked with increased fatness in women from several ethnic groups (e.g., Ness, 1991; Garn, 1980; Sharma et al., 1988). The association between fat distribution and menarche age is less clear, with some reporting a significant association between centrally distributed fat and early menarche age (Frisancho and Flegel, 1982) and others not finding a significant association (e.g., Malina and Bouchard, 1988).

There are possible negative consequences of early menarche age both for the individual and for the population. Early age at menarche is related to increased fatness throughout adult life (LaVelle, 1994) and thus places women at increased risk for obesity-related diseases.

Native Hawaiians suffer from high rates of such obesity-related diseases as noninsulin-dependent diabetes mellitus, heart disease, and breast cancer. Furthermore, native Hawaiian adults living on Hawaiian Homestead lands on Molokai, and therefore likely to have a fairly high mean percentage of Hawaiian ancestry, have been reported to have substantially higher rates of obesity than the U.S. population as a whole, and to have fat more centrally distributed based on the waist/hip ratio (Curb et al., 1991).

Previous reports noted that school-age native Hawaiian girls are significantly fatter than classmates from other ethnic backgrounds (Brown et al., 1992), and tend to have more centralized fat distributions (Brown et al., 1993). The measures of adiposity in these girls may be related to age at menarche. Accordingly, the current report

Received August 21, 1993; accepted July 25, 1995.

evaluates the relationships among age of menarche, time since menarche (TSM), ethnicity, adiposity, fat distribution, and socioeconomic status in female adolescents who reside on the Island of Hawaii and who were included in the samples discussed in the earlier reports.

METHODS

Setting and population

As part of a larger study (Brown et al., 1991) two cohorts of girls were studied, consisting of students who were in the seventh and tenth grades, respectively, at the start of the study. The study lasted 4 years, until the cohorts overlapped in age. All students in the designated grades at four schools located in the South Hilo and Puna Districts were asked to participate in the study. The schools included one of the two public intermediate schools in the city of Hilo from which seventh graders were recruited. This school draws its students from diverse neighborhoods in Hilo, including a Hawaiian Homestead region. Hawaiian Homestead lands are set aside by law for native Hawaiians, with the head of household required to be at least 50% native Hawaiian by ancestry. Both public high schools in Hilo, from which tenth graders were recruited, were included in the study, as was a rural public school in the neighboring Puna District that included both sampled grade levels and which drew some of its student body from a second Hawaiian Homestead region.

Students were characterized as either "native Hawaiian" or "non-Hawaiian," with children who claimed any ancestry from people native to Hawaii before European contact given the former classification. When informed consent forms were sent to parents, the child's designation as either native Hawaiian or non-Hawaiian based on school records was noted, and corrections were requested. A further check on ethnic affiliation was made, based on discussions with the children and home visits with family members of those designated as native Hawaiians. During the home visits genealogies were collected and used to derive estimates of percentage of Polynesian ancestry (PPA) for the girls (see Brown et al., 1991).

TABLE 1. Number and mean age of girls at the time of measurement by cohort and ethnicity

Seventh grade cohort Ethnicity	N	Mean age (±SD)
Native Hawaiians	28	13.0 ± 0.7
Non-Hawaiians	18	13.3 ± 0.6
Total	46	13.1 ± 0.7
Tenth grade cohort Ethnicity	**N**	**Mean age (±SD)**
Native Hawaiians	18	15.7 ± 0.5
Non-Hawaiians	29	15.8 ± 0.4
Total	47	15.8 ± 0.5
Grand total	93	14.5 ± 1.5

Table 1 presents the number of girls who participated in the study by cohort and ethnicity. These numbers exclude four girls for whom acceptable data on age at menarche were not ascertained (see below). Further information about the sample can be found in Brown et al. (1991). Participation rates were 38% for seventh graders and 18% for tenth graders, with native Hawaiians having higher participation rates (47% and 28% for the two grade levels) than non-Hawaiians. Records were available for height and weight for all seventh graders in one of the schools, allowing assessment of possible sample bias: there was no significant difference between height, weight, and computed body mass index (weight/stature^2) in comparisons of participants with non-participants in the study.

Measures

All children underwent an anthropometric battery annually, with the following measures taken: stature; weight; biacromial and biiliocristal diameters; circumferences at upper arm, abdomen, and calf; sitting height; arm length; and skinfolds at the triceps, biceps, medial calf, subscapular, suprailiac, and abdominal sites.

Other measures at annual examinations included a dental survey of erupted teeth, and questions of girls as to whether and when they had reached menarche. In most cases girls were able to remember their menarche date to the month and year; in some cases dates were recalled only to a season (approximately 3 month interval) in a given year, with girls excluded who could not re-

TABLE 2. Age at menarche and time from menarche to date of anthropometric measurements by cohort and ethnicity

	Age at menarche		Time since menarche	
Seventh grade cohort	Mean ± SD	Range	Mean ± SD	Range
Native Hawaiians	12.2 ± 1.0	9.8–13.9	0.8 ± 0.6	0.1–2.4
Non-Hawaiians	12.5 ± 0.9	10.3–14.2	0.8 ± 0.7	0.0–2.8
Tenth grade cohort	Mean ± SD	Range	Mean ± SD	Range
Native Hawaiians	12.5 ± 1.3	10.3–15.4	3.1 ± 1.5	0.0–6.4
Non-Hawaiians	13.0 ± 1.3	9.7–16.0	2.9 ± 1.3	0.4–5.8

member their age at menarche within a 3 month period. Menarche age was assigned to the midpoint of the recalled month or season. Age at menarche should ideally be collected prospectively, or be computed for a population based upon the status quo method with probit analysis (Healy, 1986; Eveleth and Tanner, 1990) in order to eliminate or minimize recall error. Neither of these methods were appropriate here, but the short span of time between menarche and the recall for most girls suggests that the recall data are of high quality.

Interviews with parents of the native Hawaiian children were conducted during the first year of the study for 37 of the 46 native Hawaiian participants. During this interview genealogies were completed, as well as questionnaires concerning household size and education, occupation, and income of the parents; and self-reports of the family's identity with native Hawaiian lifestyle were recorded. The girls were also individually asked to give a self-report of their degree of identification with native Hawaiian lifestyle. Percentage of Polynesian Ancestry (PPA) was derived from the genealogy, with crosschecking with other relatives and Mormon church records where possible. The PPA was categorized into quartiles, with girls assigned to "0% ancestry," "less than 25% ancestry," "between 25 and 50 percent ancestry," and so on. A social class index was computed based upon parent's education and occupation (King and Ziegler, 1975). See Brown et al. (1991) for details about these measures. Genealogies were completed for some students for whom other sociocultural data were missing: a total of 89 girls (42 of 46 native Hawaiians) were assigned PPA values.

Of the 93 girls in the study, only 14 had not yet reached menarche at their first participation in the study; of these, only two had not reached menarche by the second year of the study. For these 14 girls, anthropometric measurements taken at the examination immediately following their reported menarche were used in analyses; for the other girls, the first year's measurement data were used. Table 2 presents means, standard deviations, and ranges for the two cohorts of both age at menarche and the elapsed time from menarche to the date when the anthropometric measurements used in analyses were obtained (time since menarche, TSM).

RESULTS

Native Hawaiian girls reach menarche at a significantly younger age (one-tailed t test, $t = 1.8$, $p < 0.05$) than their non-Hawaiian classmates. When the girls' ethnic backgrounds are further subdivided into quartiles of percentage of Polynesian ancestry (PPA), no significant difference in menarche age is noted based upon PPA, as shown in Figure 1.

Table 3 presents means and standard deviations of anthropometric measurements by ethnicity and grade level. The table also shows results of two-tailed t tests between native Hawaiians and non-Hawaiians. As can be seen, among girls in the seventh grade cohort, native Hawaiian girls tend to be fatter than their non-Hawaiian classmates, while in the tenth grade cohort Hawaiian girls are taller and heavier, but not significantly fatter, than non-Hawaiians.

Figure 2 illustrates that age at menarche has a significant negative correlation with the log-transformed value of the sum of six skinfolds (log sum skinfolds) for both native Hawaiian ($r = -0.36$, $P = 0.01$) and non-Hawaiian ($r = -0.37$, $P = 0.01$) girls, as well as for the total sample ($r = -0.38$,

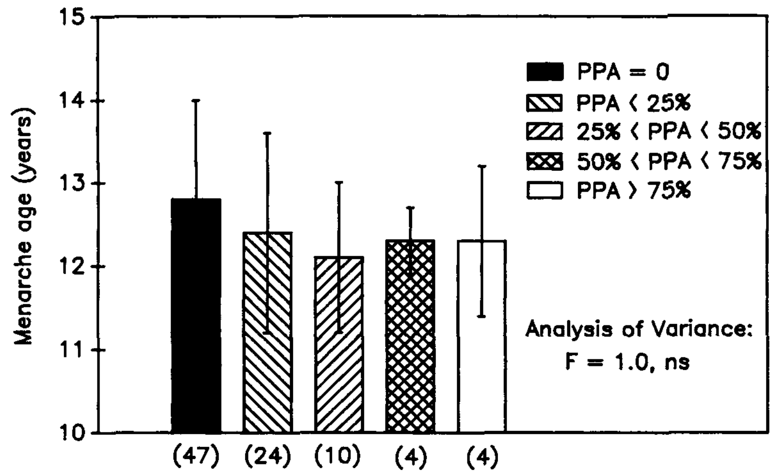

Fig. 1. Comparison of mean menarche age in adolescent females by percentage of Polynesian ancestry (PPA). Error bars represent standard deviations. Numbers in parentheses represent sample size.

$P < 0.001$). TSM has a significant positive correlation with the log sum skinfolds ($r = 0.27, P < 0.01$) for the total sample. Accordingly, both age at menarche and TSM were included in a multiple regression analysis using the log sum skinfolds as the dependent variable. Backward elimination was employed. Table 4A presents the summary of the multiple regression. As can be seen, age at menarche was significantly related to the log sum of skinfolds and remained in the model, while TSM was removed from the model.

The relationship between fatness and menarche was analyzed separately for the two cohorts. For girls in the seventh grade cohort, both age at menarche ($r = -0.15$, ns) and TSM ($r = 0.10$, ns) are not significantly correlated with the log sum skinfolds. However, for the tenth grade cohort these two variables are significantly correlated with the log sum skinfolds (for menarche age: $r = -0.61$, $P < 0.001$; for TSM: $r = 0.52$, $P < 0.001$). Multiple regression analyses employing backward elimination were carried out as above, separately for each cohort. Neither age at menarche nor TSM remained in the model for the seventh grade cohort (Table 4B). For the tenth grade cohort, TSM was removed, while age at menarche was significantly related to the log sum of skinfolds and remained in the model, as shown in Table 4C.

The girls were grouped into 1 year intervals based on TSM. In this grouping, data from successive years of the study were included; thus, for example, a girl who had reached menarche 1.5 years before the first year of the study would have her first year data included in the 1–2 year TSM group, her second year data included in the 2–3 year TSM group, and so forth. For each TSM group, correlations between age at menarche and log sum skinfolds were carried out. Figure 3 illustrates the correlation coefficients in the TSM groupings, where a trend toward greater negative correlations between age at menarche and log sum skinfolds with increasing TSM can be observed.

A principal components analysis was undertaken for the purpose of describing fat distribution. Fat distribution is related to overall fatness; therefore, analysis controlled for fatness by determining the residuals of the regression of individual, site-specific skinfolds (log transformed) on the log-transformed value of the average skinfold thickness for each girl (Baumgartner et al., 1986; Malina and Bouchard, 1988). Table 5 presents relationships between the residuals of the site-specific skinfolds on the four principal components that had eigenvalues

TABLE 3. Means ± SDs of anthropometric measurements of participants by ethnicity and grade level, with two-tailed t-tests and probabilities

Measurement	Hawaiians	Non-Hawaiians	T	*P*
Seventh grade cohort				
Stature (mm)	1,563 ± 58	1,552 ± 60	0.6	ns
Weight (kg)	51.9 ± 9.7	47.1 ± 7.6	1.8	0.08
Arm circumference (mm)	249 ± 29	233 ± 22	2.0	0.05
Abdominal circumference (mm)	729 ± 78	688 ± 56	2.0	0.05
Abdominal skinfold (mm)	21.8 ± 7.7	17.1 ± 5.5	2.3	<0.05
Suprailiac skinfold (mm)	15.9 ± 6.2	12.8 ± 5.8	1.7	0.09
Subscapular skinf. (mm)	16.2 ± 6.3	12.7 ± 3.6	2.2	<0.05
Triceps skinfold (mm)	19.0 ± 5.0	15.8 ± 3.8	2.4	<0.05
Biceps skinfold (mm)	12.0 ± 4.4	10.7 ± 3.1	1.0	ns
Calf skinfold (mm)	17.2 ± 5.2	15.2 ± 2.6	1.5	ns
Sum of six skinf. (mm)	102.1 ± 29	85.3 ± 20.8	2.1	<0.05
Tenth grade cohort				
Stature (mm)	1,616 ± 53	1,565 ± 77	2.6	0.01
Weight (kg)	58.3 ± 10.9	51.0 ± 9.4	2.5	<0.05
Arm circumference (mm)	265 ± 40	252 ± 36	1.2	ns
Abdominal circumference (mm)	753 ± 107	718 ± 95	1.2	ns
Abdominal skinfold (mm)	20.1 ± 5.5	18.7 ± 6.4	0.8	ns
Suprailiac skinfold (mm)	15.6 ± 5.6	13.1 ± 5.2	1.6	ns
Subscapular skinf. (mm)	18.2 ± 7.5	15.2 ± 5.3	1.7	ns
Triceps skinfold (mm)	20.4 ± 7.3	19.1 ± 5.2	0.8	ns
Biceps skinfold (mm)	13.6 ± 7.0	11.7 ± 4.8	1.1	ns
Calf skinfold (mm)	18.3 ± 7.1	19.5 ± 4.6	0.7	ns
Sum of six skinf. (mm)	106.3 ± 34	97.3 ± 26	1.0	ns

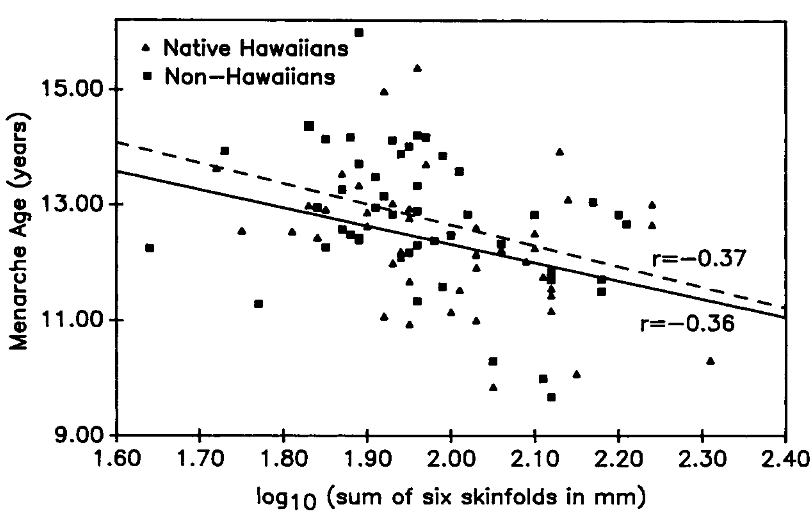

Fig. 2. Linear regression of menarche age and log-transformed sum of skinfolds for native Hawaiian (triangles, solid line) and non-Hawaiian (squares, dashed line) adolescent females.

greater than one. Component one is interpreted as contrasting suprailiac fat with fat on the lower limb (medial calf), component two contrasts biceps with abdominal fat, component three contrasts subscapular with abdominal and biceps fat, and component four largely represents triceps fat. Native Hawaiian girls had significantly higher values of component one than non-Hawaiian girls (two-tailed t tests, $t = 2.0$, $P < 0.05$), but there were no significant ethnic differences in the other components. The four principal components representing fat distribution were included in a multiple regression analysis which utilized backward elimination, using menarche age and TSM as

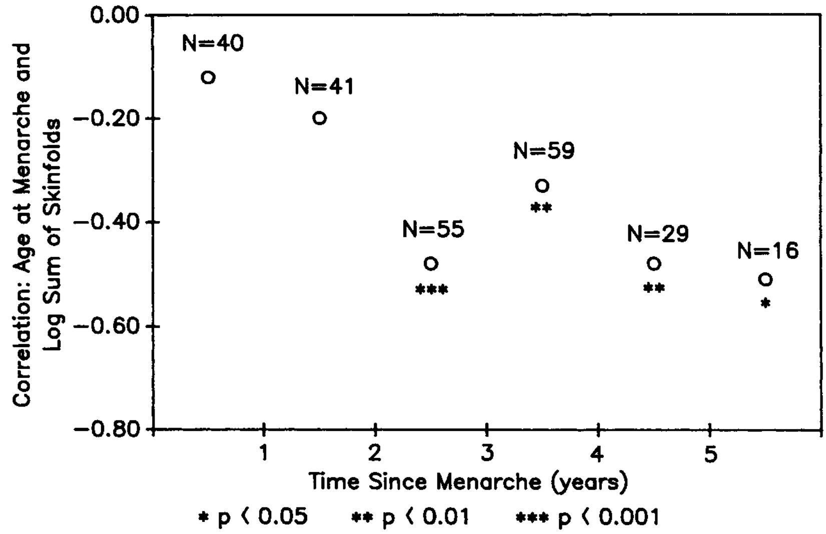

Fig. 3. Correlation coefficients of age at menarche and log sum of skinfolds for girls for different intervals of time since menarche.

TABLE 4. Summaries of multiple regressions using backwards elimination; age at menarche and TSM as predictors of log sum of skinfolds

A. For total sample (n = 93):		
For completed model, log sum of skinfolds as dependent variable:		
$R^2 = 0.16$, $F = 17.0$, $P < 0.001$		
Variables in model:		
Age at menarche	T = −4.1	$P < 0.001$
(Constant)	T = 19.7	$P < 0.001$
Variables removed from model:		
TSM	T = 1.6	ns
B. For seventh grade cohort (n = 46):		
No variables remained in the model.		
Variables removed from model:		
Age at menarche	T = −1.4	ns
TSM	T = 0.8	ns
C. For tenth grade cohort (n = 47):		
For completed model, log sum of skinfolds as dependent variable:		
$R^2 = 0.37$, $F = 26.4$, $P < 0.001$		
Variables in model:		
Age at menarche	T = −5.1	$P < 0.001$
(Constant)	T = 19.6	$P < 0.001$
Variables removed from model:		
TSM	T = −1.2	ns

independent variables. For component one, both variables remained in the model, while for the other components, both variables were removed from the model (see Table 6).

Relationships between ethnic, socioeconomic, and other cultural variables and menarche age were observed for the 37 subjects for whom family interviews had been carried out. Bivariate correlations between menarche age and the sociocultural variables income ($r = 0.10$), social class index ($r = 0.01$), household size ($r = -0.28$), and reported identification with Hawaiian culture ($r = 0.08$) were all nonsignificant. Because these variables are interrelated in this sample (Brown et al., 1991), a second principal components analysis was undertaken which sought to identify a small number of independent components related to PPA, household size, family income, social class index, and reported identification with Hawaiian culture. Table 7 shows the relationship between the above variables and the two identified components with eigenvalues greater than one. Component one is positively related to income and the social class index, and negatively related to reported identity with Hawaiian culture, while component two is positively related to family size and PPA.

Next, the two principal components derived from sociocultural measures were included with TSM in a multiple regression analysis using menarche age as the dependent variable. Backward elimination was used in the analysis. Neither of the sociocultural components were significantly related to menarche age.

TABLE 5. Relationship of residuals of log-transformed individual skinfolds regressed on the average skinfold thickness with components derived from principal components analysis

Residuals of individual skinfolds	Component one	Component two	Component three	Component four
Triceps	0.01	0.04	−0.13	0.99
Biceps	0.09	0.85	−0.38	−0.13
Medial calf	−0.94	0.02	−0.01	−0.12
Subscapular	0.12	−0.06	0.92	−0.15
Suprailiac	0.86	−0.02	0.09	−0.13
Abdomen	0.18	−0.78	−0.40	−0.31
Eigenvalue	1.75	1.41	1.15	1.01
% Variation explained	29.2	23.5	19.2	16.9

TABLE 6. Summaries of multiple regressions using backward elimination; age at menarche and TSM as predictors of principal components of fat distribution

A. For principal component one:		
For completed model:		
$R^2 = 0.10$, $F = 4.9$, $P < 0.01$		
Variables in model:		
Age at menarche	T = −2.1	$P < 0.05$
TSM	T = −3.0	$P < 0.01$
(Constant)	T = 2.3	$P < 0.05$
Variables removed from model:		
None		
B. For principal component two:		
No variables remained in the model.		
Variables removed from model:		
Age at menarche	T = −0.8	ns
TSM	T = 1.5	ns
C. For principal component three:		
No variables remained in the model.		
Variables removed from model:		
Age at menarche	T = 1.1	ns
TSM	T = 0.4	ns
D. For principal component four:		
No variables remained in the model.		
Variables removed from model:		
Age at menarche	T = 0.5	ns
TSM	T = 1.6	ns

TABLE 7. Principal components analysis of percentage of Polynesian ancestry, household size, income, and reported identity with Hawaiian culture

Variable	Component one	Component two
Percentage Polynesian ancestry	0.04	0.84
Cultural identity	−0.48	0.18
Household size	−0.16	0.76
Income	0.89	0.10
Social class index	0.85	−0.05
Eigenvalue	1.82	1.29
% Variation explained	36.3	25.9

DISCUSSION

The mean age at menarche for the native Hawaiian girls in this study, 12.2 for the seventh grade cohort and 12.5 for the tenth grade cohort, is somewhat earlier than reported for other Polynesian girls as well as for the U.S. average of 12.8 years (Tanner, 1988). For instance, urban Tahitian girls residing in Papeete have a median age at menarche of 12.6 (Ducros and Ducros, 1987), Maori girls have been reported to have a median age at menarche of 12.7 (Eveleth and Tanner 1990), and Samoan migrants to Honolulu reach menarche "between 13 and 14 years" (Bindon and Zansky, 1986). The non-Hawaiian girls in this sample have an age at menarche similar to the U.S. average. Utilizing a recall method to establish age at menarche represents a weakness for the study, but the small mean TSM as well as the similar values of age at menarche for non-Hawaiians in the sample and overall U.S. averages suggests that these values are fairly accurate.

Much research has been carried out on the causes of early age at menarche, with strong evidence for an important effect of increased fatness on many measures of early maturity (Beunen et al., 1994) including age at menarche (Maclure et al., 1991). Danker-Hopfe (1986) has presented evidence for a cline in menarche age among European populations, which she suggests may be related to genetic influences on this measure of maturation rate. There is a greater concordance for menarche age among monozygotic than dizygotic twins (Bailey and Garn, 1986), supporting the idea of a genetic component to menarche age. The secular trend for a decreased menarche age is strong evidence for the importance of environmental determinants of menarche age, however. It is less clear what specific aspects of the environment are most important for influencing the rate of matura-

tion of girls. Improved health and nutrition are commonly cited as important physical factors, while social factors such as socioeconomic status and family size are also frequently observed correlates of menarche age (e.g., Van Wieringen, 1986).

The results reported here suggest that the ethnicity of girls in Hawaii, independent of their level of fatness, is not a significant predictor of menarche age. The observed earlier menarche age in native Hawaiian girls compared to their classmates appears to be due to their greater average fatness. While the data presented here show greater postmenarche fatness in native Hawaiians, a previous report documented greater fatness in younger, premenarchal native Hawaiian girls compared with their non-Hawaiian classmates (Brown et al., 1992). The influence of fatness on ethnic differences in age at menarche is substantiated by the nonsignificant relation between degree of Polynesian ancestry and menarche age in the girls. Thus, environmental factors, specifically adiposity, appear to be the major determinants of age at menarche.

Also, measures related to socioeconomic and cultural variability among the girls are not significantly related to menarche age. This is true both for the individual sociocultural measures and for the principal components derived from these measurements. Thus, this sample of native Hawaiian girls differs from other populations where significant relationships between socioeconomic variables and age at menarche have been observed.

Body fatness is increased in girls who have had earlier menarche age (Maclure et al., 1991; Wellens et al., 1992). This may be due to increased estrogen levels in adolescence and early adulthood in girls reaching menarche at an early age, with the estrogen stimulating increased accumulation of body fat (Wellens et al., 1992). As noted above, early menarche age is also associated with increased fatness of preadolescents (cf., Marshall and Tanner, 1986), suggesting that the link between fatness and menarche age may be two way.

The results of this study show that girls with early age at menarche tend to be fatter than girls who mature later. This difference is not statistically significant until about 2 years after menarche, however, and the difference in fatness between early and late maturers increases as TSM increases, at least until 6 years after menarche, which is the latest TSM covered in this study. This increased adiposity in females who have early age at menarche may have important health consequences for them in the long term, as noted by LaVelle (1994). Early age at menarche also is a risk factor for breast cancer independent of fatness (Hsieh et al., 1990; Kvåle and Heuch, 1988). The very high mortality from breast cancer among native Hawaiian women (Burch, 1984; LeMarchand et al., 1984) may therefore be related to both early age at menarche and high levels of adiposity.

The results of this study also suggest that fat distribution is significantly related to age at menarche. There is a significant increase in principal component one of fat distribution, indicating relatively greater amounts of fat in the trunk (specifically in the suprailiac site) as opposed to lower limbs, with increasing age at menarche and with increasing TSM. Thus, early age at menarche is associated both with increased fatness in adolescents and with a distribution of fat in the suprailiac region. This type of fat distribution is considered a risk factor for chronic diseases independent of total adiposity (e.g., Freedman and Rimm, 1989).

Given the importance of early age at menarche as a risk factor for chronic diseases later in life, further research is necessary to disentangle factors that *predispose toward* from those that *result from* early age at menarche. This is particularly important because adiposity, itself an important risk factor for chronic disease, is both a cause and effect of early age at menarche. A better understanding of these factors will require analysis of prospective studies that track girls from preadolescence to adulthood such as LaVelle's (1994) report on data from the Tecumseh Community Health Surveys.

ACKNOWLEDGMENTS

Dr. Jerry Johnson and Dr. Craig Severance provided assistance in all aspects of this study. We also thank Laura Young, Deborah

Chun, Cheryl Leialoha, Melissa Kirkendall, and Ehukai Sako for their help with data collection, and appreciate the *kokua* of our participants. The research was supported by NIH-MBRS Grant 3-SO6-RR08073-17.

LITERATURE CITED

Bailey SM, and Garn SM (1986) The genetics of maturation. In: F Falkner and JM Tanner (eds.): Human Growth: A Comprehensive Treatise, Vol 3. Second Edition. New York: Plenum, pp. 169–195.

Baumgartner RN, Roche AF, Guo S, Lohman T, Boileau RA, and Slaughter MH (1986) Adipose tissue distribution: The stability of principal components by sex, ethnicity and maturation stage. Hum. Biol. *58:*719–735.

Beunen GP, Malina RM, Lefevre JA, Claessens AL, Renson R, and Vanreusel B (1994) Adiposity and biological maturity in girls 6–16 years of age. Int. J. Obes. *18:*542–546.

Bindon JR, and Zansky S (1986) Growth and body composition. In: PT Baker, JM Hanna, and TS Baker (eds.): The Changing Samoans. New York: Oxford, pp. 222–253.

Brown DE, Johnson JL, and Severance CJ (1991) Growth of native Hawaiian school children: I. Research design, stature and weight measurements. Am. J. Hum. Biol. *3:*677–688.

Brown DE, Severance CJ, Sako EK, Chun DY, Young LL, and Johnson JL (1992) Growth of native Hawaiian school children: II. Body mass index and skinfold measurements. Am. J. Hum. Biol. *4:*433–445.

Brown DE, Koenig TV, Demorales AM, Mossman KK, Akina CM, and Sako EK (1993) Relation of subcutaneous fat distribution to percentage of Polynesian ancestry in native Hawaiian children. Am. J. Hum. Biol. *5:*9–15.

Burch TA (1984) Cancer from selected sites in Hawaiians compared with other races in Hawaii 1968–1972 and 1978–1982. Research and Statistics Report No. 48. Honolulu: Hawaii State Department of Health.

Curb JD, Aluli NE, Kautz JA, Petrovitch H, Knutsen SF, Knutsen R, O'Conner HK, and O'Conner WE (1991) Cardiovascular risk factor levels in ethnic Hawaiians. Am. J. Public Health *81:*164–167.

Danker-Hopfe H (1986) Menarcheal age in Europe. Yearb. Phys. Anthropol. *29:*81–112.

Ducros J, and Ducros A (1987) Age at menarche in Tahiti. Ann. Hum. Biol. *14:*559–562.

Eveleth PB, and Tanner JM (1990) Worldwide Variation in Human Growth. Second Edition. Cambridge: Cambridge University Press.

Freedman DS, and Rimm AA (1989) The relation of body fat distribution, as assessed by six girth measurements, to diabetes mellitus in women. Am. J. Public Health *79:*715–720.

Frisancho AR, and Flegel PN (1982) Advanced maturation associated with centripetal fat pattern. Hum. Biol. *54:*717–727.

Garn SM (1980) Continuities and change in maturational timing. In: OG Brim and J Kagan (eds.): Constancy and Change in Human Development. Cambridge: Harvard University Press, pp. 113–162.

Healy MJR (1986) Statistics of growth standards. In: F Falkner and JM Tanner (eds.): Human Growth: A Comprehensive Treatise. Vol 3. Second Edition. New York: Plenum Press, pp. 47–58.

Hsieh C-C, Trichopoulos D, Katsouyanni K, and Yuasa S (1990) Age at menarche, age at menopause, height and obesity as risk factors for breast cancer associations and interactions in an international case–control study. Int. J. Cancer *62:*1625–1631.

King M, and Ziegler M (1975) Research Projects in Social Psychology. Monterey, CA: Brooks/Cole.

Kvåle G, and Heuch I (1988) Menstrual factors and breast cancer risk. Cancer *62:*1625–1631.

LaVelle M (1994) Are there long-term health consequences of secular trend in early menarche? Coll. Antropol. *18:*53–61.

LeMarchand L, Kolonel LN, and Nomura AMY (1984) Relationship of ethnicity and other prognostic factors to breast cancer survival patterns in Hawaii. J. Natl. Cancer Inst. *73:*1259–1265.

Maclure M, Travis LB, Willett W, and MacMahon B (1991) A prospective cohort study of nutrient intake and age at menarche. Am. J. Clin. Nutr. *54:*649–656.

Malina RM, and Bouchard C (1988) Subcutaneous fat distribution during growth. In: C Bouchard and FE Johnston (eds.): Fat Distribution During Growth and Later Health Outcomes. New York: Alan R. Liss, pp. 127–145.

Marshall WA, and Tanner JM (1986) Puberty. In: F Falkner and JM Tanner (eds.): Human Growth, Vol 2. New York: Plenum, pp. 171–209.

Ness R (1991) Adiposity and age of menarche in Hispanic women. Am. J. Hum. Biol. *3:*41–48.

Sharma K, Talwar I, and Sharma N (1988) Age at menarche in relation to adult body size and physique. Ann. Hum. Biol. *15:*431–434.

Tanner JM (1988) Human growth and constitution. In: GA Harrison, JM Tanner, DR Pilbeam, and PT Baker (eds.): Human Biology. Oxford: Oxford, pp. 337–435.

Van Wieringen JC (1986) Secular growth changes. In: F Falkner and JM Tanner (eds.): Human Growth, Vol. 3. New York: Plenum, pp. 307–331.

Wellens R, Malina RM, Roche AF, Chumlea WC, Guo S, and Siervogel RM (1992) Body size and fatness in young adults in relation to age at menarche. Am. J. Hum. Biol. *4:*783–787.